3.3 Hydrology and Geothermal Resources

REGIONAL HYDROLOGY

The project site is located in Modoc County, along the Pit River, one of the County's major hydrological features. The Pit River is the major river in Northeast California and one of the larger tributaries of the Sacramento River (CVRWQCB 1994). Water from the Pit River is currently used for agriculture, recreation and provides habitat for fresh-water fish. Pit River water is not used for municipal drinking water directly, although may be used indirectly from the Sacramento River. Groundwater is the primary source of water for towns along the Pit River.

Surface Water

Lakes and reservoirs are common within the region. Modoc County has the second highest area (248 mi^2) of surface water of all counties in California (Mintier Harnish 1988a). Goose Lake, the largest lake in the County, is located north of the project area in the headwater area of the Pit River. As a terminal lake, its area fluctuates around approximately 110 mi^2. When it is considerably larger, it can over flow into the North Fork of the Pit River. The high salinity and alkali content of Goose Lake make the water unsuitable for irrigation (Mintier Harnish 1988a). See Figure 3.3-1 and 3.3-2, Pit River Flow Data.

The project site is located within the Warm Springs Valley Drainage Basin (Figure 3.3-3), a sub-basin of the Pit River Basin. The Pit River is the largest river in northeastern California, drains the northeastern section of the state, and enters the Sacramento River at Shasta Lake. The north fork of the Pit River starts at Goose Lake, the south fork begins high in the Warner Mountains. The forks converge near Alturas, just east of the project area. The river flows through large, high mountain valleys and cuts its way through massive basalt flows to form canyons that exhibit unusual geological formations that promote a variety of wildlife species unique to these landscapes (CVRWQCB 1994). The project area is located in one of the major drainage basins of the Pit River (approximately 544 mi^2) as described in Table 3.3-1 below (DWR 1974).

Table: 3.3-1: Pit River Drainage Basin, Surface Water, Annual Surface Flows and Water Supply (Thousands of Acre-feet)

Basin/ Subarea	Estimated Drainage Area (Sq. Miles)	Mean Annual Natural Flow of Surface Water	Present (1974) Flow			Potential Flow		
			Surface	Ground	Total	Surface	Ground	Total
Goose Lake	363	50	19.3	4.0	23.3	24.8	7.0	31.8
North Fork Pit	237	49	26.4	3.0	29.4	30.6	4.2	34.8
South Fork Pit	485	70	68.3	4.0	72.3	79.4	5.9	85.3
Warm Springs Valley	544	31	48.0	2.0	50.0	50.2	4.1	54.3
Big Valley	706	135	18.3	3.4	21.7	20.8	3.9	24.7
McArthur	55	4	2.1	0.0	2.1	3.1	0.0	3.1
Total	2,390	339	182.4	16.4	198.8	208.9	25.1	234.0

SOURCE: DWR 1974

Groundwater

The site is located within the Alturas Groundwater Basin. The Alturas groundwater basin is approximately 100 mi^2. Groundwater resources typically occur in the shallow "Older Alluvium". The shallow alluvium is underlain by volcanic and volcanogenic sediments that typically have low permeability, although a few permeable zones may occur locally. Therefore, most of the groundwater resources in the area are typically shallow, although some wells are as deep as 800 feet. Wells typically yield 400 gallons per minute (gpm) up to a maximum of 1000 gpm (in 1974), and the entire basin has a storage capacity of 1,600,000 acre-feet. In the mid-seventies, approximately 9,000 acre-feet were being pumped from the basin annually; the basin has an estimated safe annual yield of approximately 17,000 acre-feet (DWR 1974).

With limited groundwater resources within much of the Plateau, rainfall or snow melt provides much of the recharge to both surface and ground waters. The Alturas Groundwater basin receives recharge from the higher elevation areas to the north and to a lesser extent, south of the Pit River. The climate in the project area is characterized by warm, dry summers and cool, moist winters. Average annual precipitation is 15-19 inches.

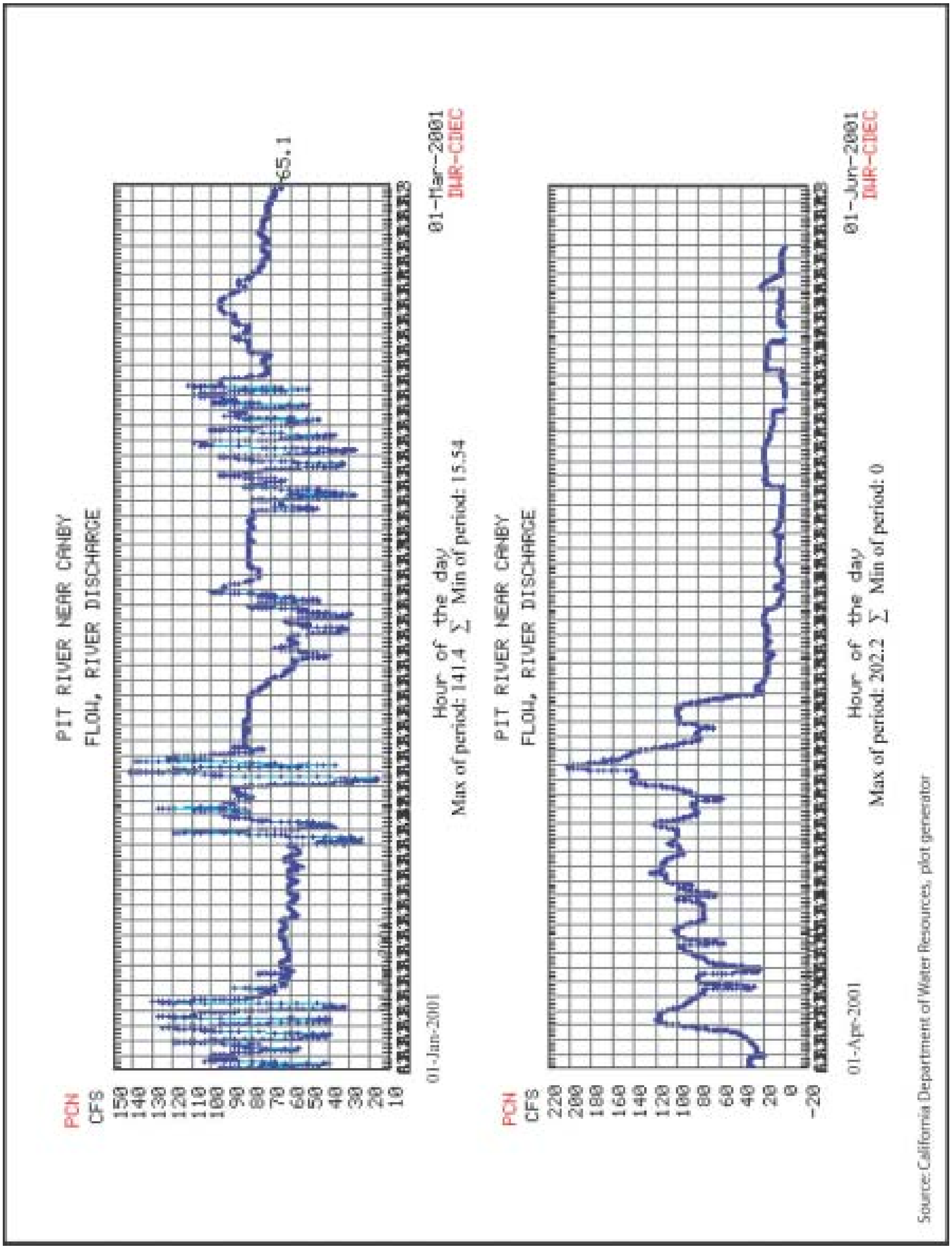
The Canby region is located in a complex geologic region between the *Cascade Range* and the *Basin and Range Region*. This tectonic setting produces a high temperature gradient (approximately 7°F/100 feet). The gradient provides the heat source for warm to moderate temperature groundwater aquifers at depths of over 1,000 feet. Where lithification and fractures provide permeability within the volcanic sequence, geothermal fluids can occur. Some of these warm waters flow to the surface as natural warm or hot springs.

Five thermal water areas, twenty-two thermal springs, and twenty-three thermal wells are reported in the Modoc County General Plan. Thermal waters, wells, and springs occur throughout the Pit River Valley from Alturas west to Canby. This section of the Pit River Valley includes four main springs including Kelley Hot Springs. The geothermal resources are discussed in detail below.

Water Quality

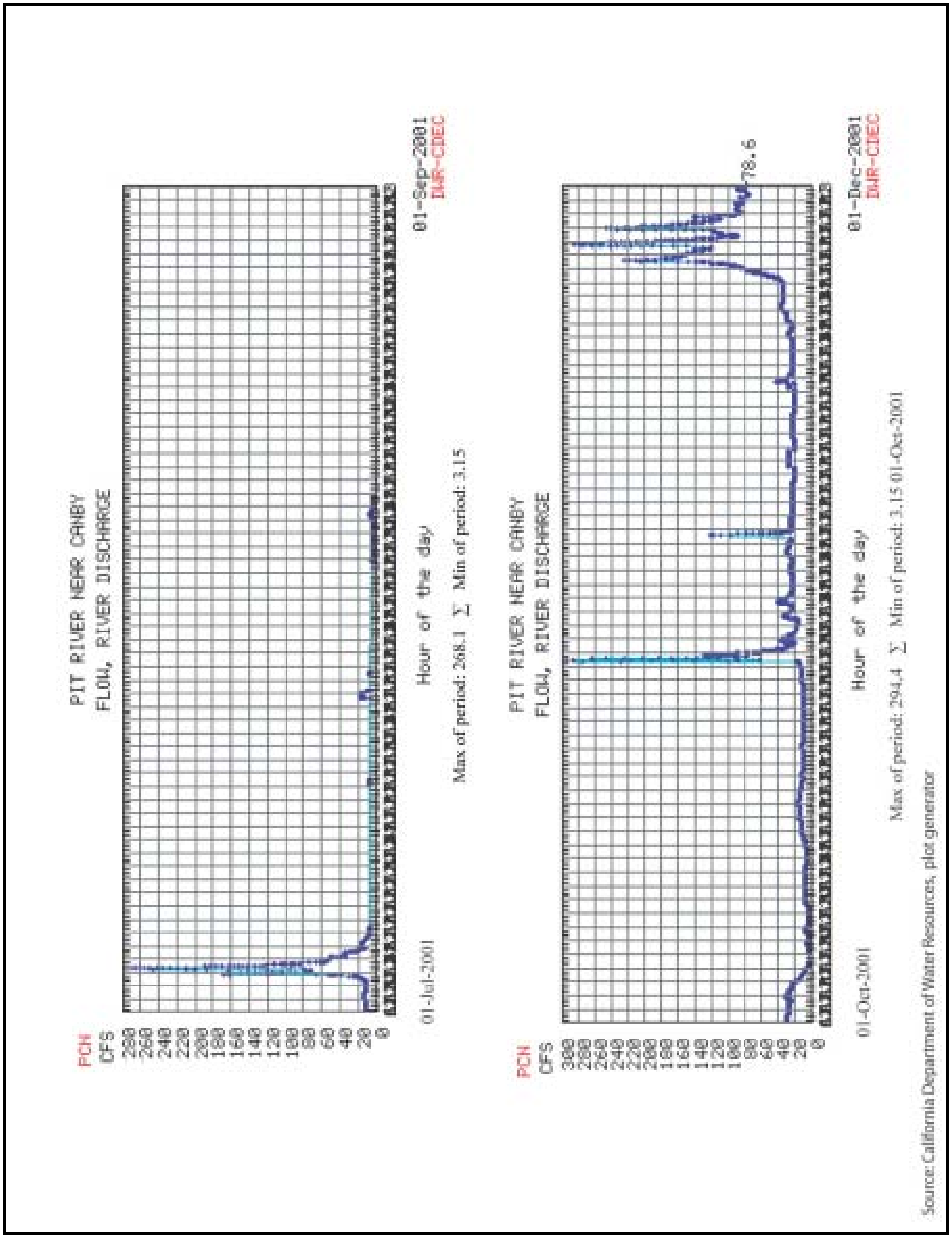
Water quality of surface and groundwater in the region is typically excellent. Some surface waters are terminal lakes, and as such, accumulate high concentrations of salts and minerals, including boron and arsenic. Although industrial impacts are rare, some agriculturally impacted surface and ground waters occur within the area; these impacted waters are typically identified by elevated nitrate concentrations. In addition, naturally occurring warm springs such as Kelley Hot Springs contribute elevated mineral and trace metal concentrations to the recharge of the Pit River.

Figure 3.3-1: Pit River Flow Data January–June 2001



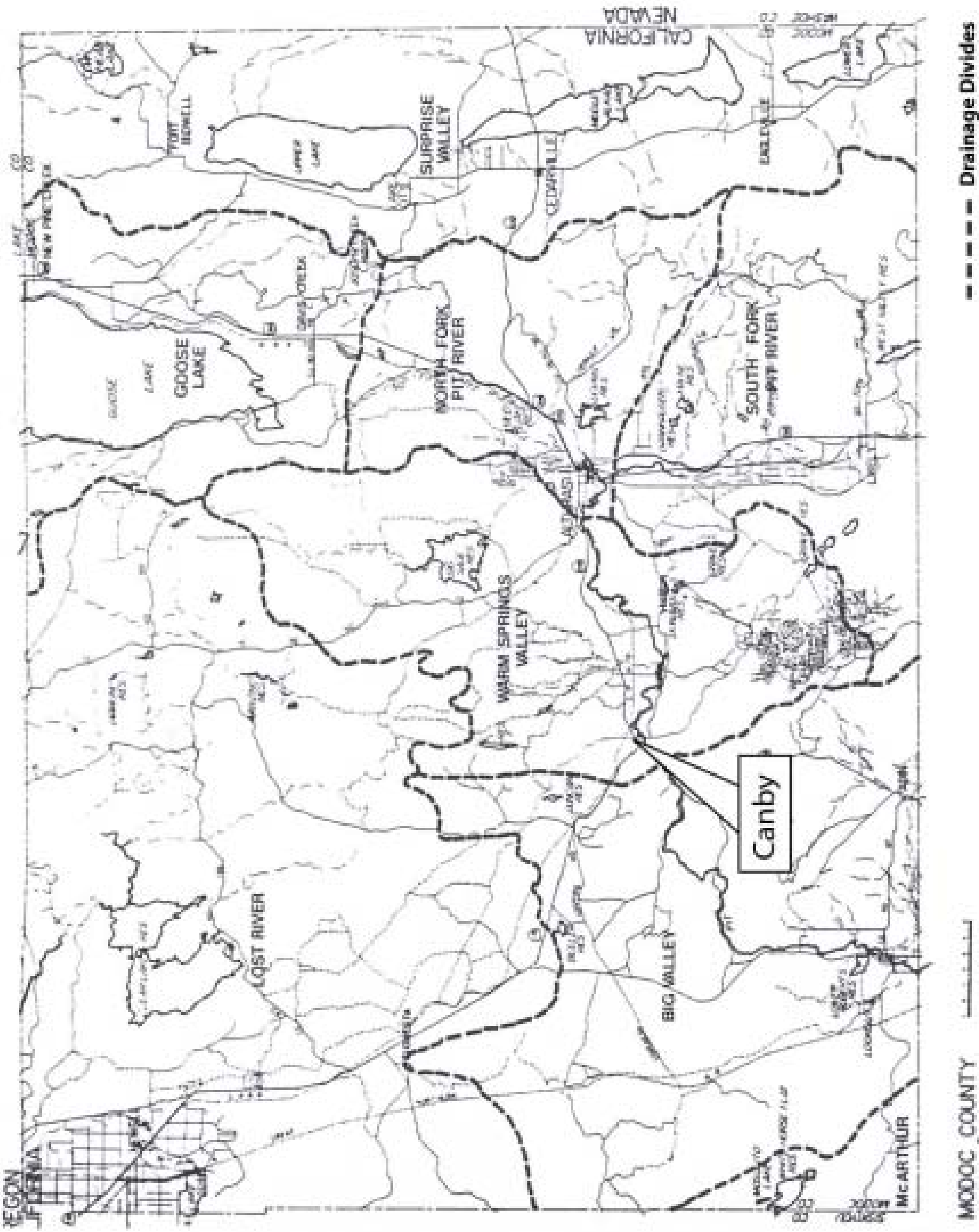
SOURCE: California Department of Water Resources 2001

Figure 3.3-2: Pit River Flow Data July–December 2001



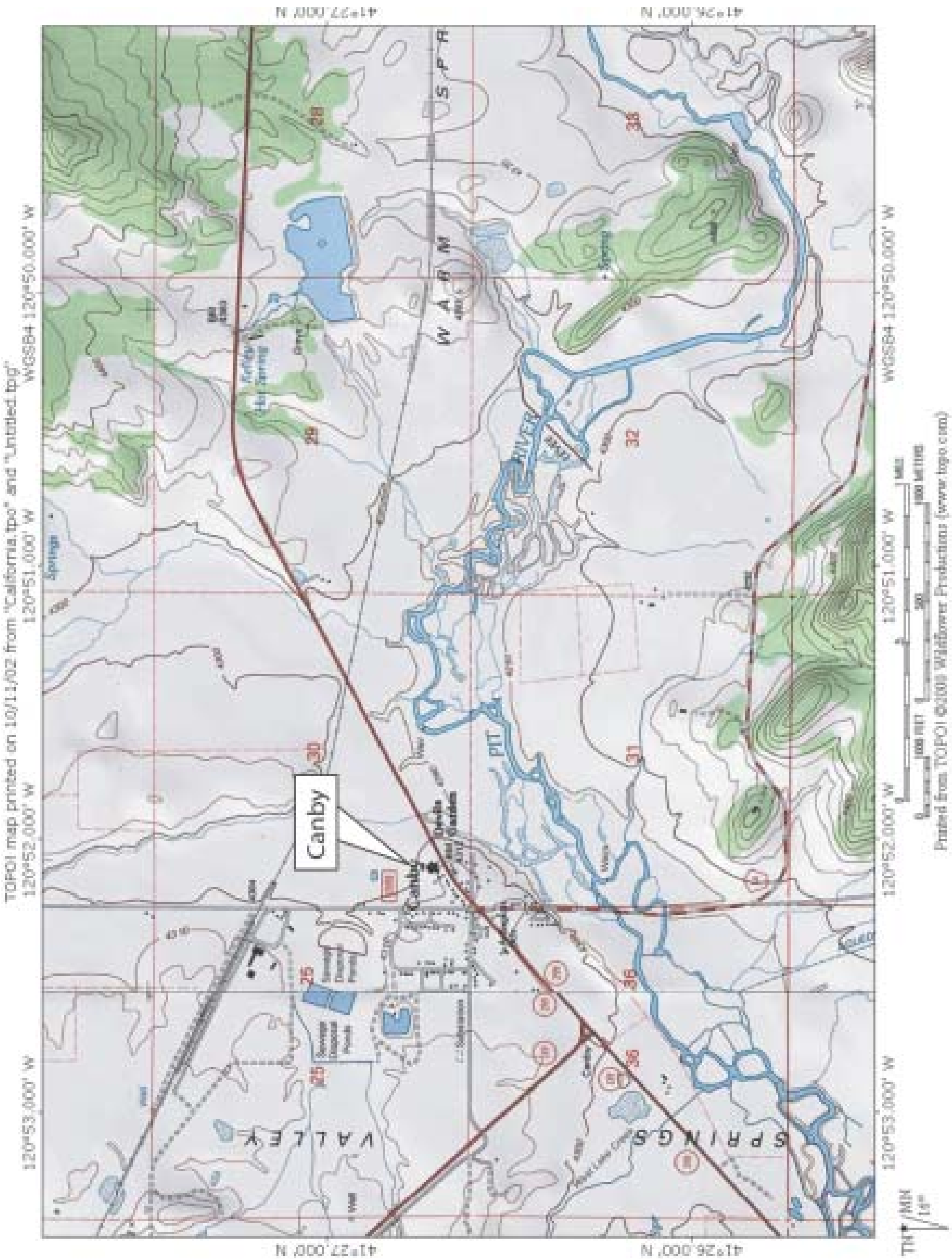
SOURCE: DWR 2001

Figure 3.3-3: Modoc County Drainage Basins



SOURCE: Mintier Harnish & Associates 1988a

Figure 3.3-4: Hydrology Map



SOURCE: Wildflower Productions 2000

LOCAL HYDROLOGY

Local Surface Water

In the immediate vicinity of the project area, the westerly flowing Pit River dominates the surface waters (Figure 3.3-4). Tributaries flow into the river through the project area from the north and west including Westlake Creek and Blacks Canyon Creek. There are two reservoirs within the area. The smaller reservoir is immediately west of the well site and the other, the Duncan reservoir, contains over 1000 gallons and is located near Kelley Hot Springs on a tributary of the Pit River.

Table 3.3-2: Water Quality of the Canby Region

Element/ Substance	I'SOT Geothermal Well[1]	Kelley Hot Springs[1]	Pit River 4 miles south of Canby[2*]	Pit River North Fork near Alturas[2*]	Local GW[1]	Water Quality Objectives[3]
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ca	14	20	18.77	25.15	15	-
Mg	<0.01	<0.01	7.55	10.614	8	-
Na	240	250	27.75	26.16	69	-
K	3.7	6.5	4.36	4.048	-	-
SO_4	280	300	13.50	11.83	51	250[4]
Cl	170	160	9.33	3.67	24	250
HCO_3	44	47	-	-	196	-
NO_3	<0.3	-	-	-	0.5	1
SiO_2	110	-	-	-	-	-
F	1.9	2.1	-	-	0.3	4, 2[4]
B	3.67[*]	3.8	0.26	<0.1	-	-
pH	8.65	-	8.1	7.9	-	6.5-8.5[4]
TDS	752	783	189	211.6	356	1,300,000(t) 500[4]
As	0.102[*]	0.117	0.0035	0.0036	-	0.010
Hg	0.188*	0.015	<0.001	<0.001	-	0.002

[1]I'SOT Well data, Kelly Hot Spring data, and local groundwater (GW) data from Burkhard Bohm, Plumas Geo-Hydrology, *Well Testing at the ISOT-1 Geothermal Well, Canby, Modoc County, CA,* October 18, 2000
[2]Pit River average values from California Department of Water Resources (1996-2002)
[3]Maximum Contaminant Limit, Safe Drinking Water Act, March 2002, Primary National Standards
[4]MCL from Safe Drinking Water Act, March 2002, Secondary National Standards
[*]Averaged values

SOURCE: DWR 2002a

The U.S. Geological Survey monitors water flow in the Pit River continuously at a location near Canby (Site PCN, elevation 4,266 ft. asl, 41.406° N, 120.927°) (see Figures 3.3-1 and 3.3-2). Flows are highly variable and correlate with the extreme variations in precipitation that Modoc County experiences from season to season; winter flows are much higher than summer flows. As can be seen in Figures 3.3-1 and 3.3-2, 2001 winter flows averaged approximately 70 cubic feet per second (cfs) and summer averages were around 3 cfs (DWR 2001). In that same year, flow rates varied from a high of 292 cfs to a low of 0 cfs. Extreme fluctuations during summer months are likely caused by rainstorms or regulated dam flow. The summer season of 2001 was unusually dry and Pit River levels were unusually low (Rohrbach 2002). There was no water in the Pit River upstream of Alturas until the point where the Alturas wastewater facility discharges into the river (Rohrbach2002). Water quality of the Pit River is excellent. Key constituents and concentrations for the Pit River and nearby waters are summarized in Table 3.3-2.

Local Groundwater

Based on groundwater wells in the area, groundwater resources occur within the alluvium underlying the project site. Groundwater levels appear to follow precipitation with both seasonal and year-to-year variation. Currently, water levels are at approximately 4,280 ft above sea level (asl) near the project well site, falling to 4,260 ft asl further south towards the river (DWR 2002a).

Groundwater quality in the project area is excellent. An average of seven local wells set <300 ft in total depth suggests Total Dissolved Solids (TDS) are less than 400 mg/L and all other values are less than Maximum Contaminant Levels (MCLs).

GEOTHERMAL RESOURCES

Geothermal resources occur in many parts of the Modoc Plateau ranging from the high-temperature resources at Medicine Lake Highlands and the Glass Mountain KGRA (>300 °F) to low to moderate temperature (100 to 300 °F) resources in Surprise Valley to the east of the project area. While the Glass Mountain geothermal system appears to be related to Cascade Range volcanism, the Surprise Valley Geothermal Resource appears to be a Basin and Range type of fault-controlled system (Weiss 1997). The geothermal resource at the project site is defined by the project well and similar wells located near Kelley Hot Springs, Alturas, and possibly Bieber. Although there is no evidence that this geothermal resource is continuous, it appears to occur at locations where regional high heat flow can transfer heat to water at appropriate depths and sufficient permeability exists to provide a production zone. All of these wells appear to produce warm water from a flat-lying zone of fractured lithified tuff, below 1,600 to 2,000 ft bgs, at approximately 180° to 240°F.

The project site area appears to be underlain by an extensive geothermal aquifer below 1,600 feet. The aquifer appears to extend from Kelley Hot Springs to Canby. Although the geothermal resource appears to occur within an almost flat-lying aquifer, it does not appear to be strictly stratigraphically controlled. Rather, the aquifer appears to occur when conditions allow the clay-rich volcanic rocks to become brittle and fracture.

The aquifer occurs within fractured lithified layers of the clay-rich, typically low- permeability volcanic rocks, typical of the Modoc Plateau. Since lithification is a prerequisite for sustaining fracture permeability. In these clay-rich rocks, and elevated temperatures accelerate lithification, higher heat flow may actually create the conditions that generate the aquifer. The correlation of variable depths of the thermal aquifer and variable temperature gradients also suggest that the depth of the aquifer is temperature- and permeability-controlled, rather than stratigraphically controlled.

At Kelley Hot Springs, the maximum temperature was 239°F at 1,600 feet bgs, indicating a temperature gradient from the surface to 1,600 feet of 11°/100 feet. That well became isothermal below 1600 feet and therefore the average temperature gradient over the total depth of the well of 3000 feet was 6.1 °F /100 feet. Temperature gradients in the Canby School Well No. 1 were 7 °F /100 feet to about 800 feet bgs. Temperature gradients measured in the project site well average 7.3 °F /100 feet over 2,000 feet.

The Kelley Hot Springs wells produced fluid from lithified and fractured volcanic rocks below 1600 feet. Both Alturas geothermal wells (AL-1 and AL-2) encountered geothermal fluids in lithified tuffs below 1800 feet bgs.

The similarities in temperature gradients and occurrence of the geothermal fluids in the Alturas, Bieber, Kelly Hot Springs, and I'SOT wells suggest the following common features of the geothermal reservoir (Drilling Geothermal Well I'SOT 2000):

- Production zones are associated with fractured lithified tuffs at > 1800 feet bgs.
- Temperature gradients above the lithified zones are approximately 7 °F /100 ft reflecting similar thermal properties,
- Reservoir temperatures at approximately 2000 ft bgs are at least 185°F and typically >200°F.

Like most geothermal resources, the productivity of wells completed in this aquifer depends on the nature of the well and the aquifer. Most wells completed in the aquifer appear to produce between 5 and 600 gpm. The project site well is capable of sustained production at approximately 40 gpm. The aquifer transmissivity was evaluated in Alturas and I'SOT at approximately 800 gpd/ft (Allen 1986).

The chemistry of geothermal fluids produced from the project site is similar to Kelley Hot Springs, as shown in Table 3-4.2.

FLOOD HAZARDS

100-Year Floodplain

The pipeline portion of the project extends to the edge of the Pit River and is within the flood plain of the river (Figure 3.2-4). The well and other facilities are within the town of Canby and are outside the area of concern for flooding.

The Pit Series soils have low permeability and high potential for flooding. Flooding can be frequent during the winter months in the immediate vicinity of the River. Flooding is not an issue in the summer because river flows are low. Flooding above the weir at the proposed point of discharge is manually controlled at the weir.

REGULATORY FRAMEWORK

Federal

National Pollutant Discharge Elimination System (NPDES). The Federal Pollution Control Act of 1972 as amended by the Clean Water Act in 1977 makes discharging pollutants from a point source to navigable waters illegal without a permit. In the project area, the Central Valley Regional Water Quality Control Board (CVRWQCB) administers and enforces the Clean Water Act. Waste Discharge Requirements for the proposed project were adopted on 13 May 2002.

In 1990, the Environmental Protection Agency (EPA) promulgated rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) storm water program. The Storm Water Phase II Rule extends coverage of the NPDES storm water program to certain "small" MS4s (operations serving populations of 100,000 or greater) located in "urbanized areas" (UAs), and on a case-by-case basis those small MS4s (including those between 1 to 5 acres) located outside UAs that the NPDES permitting authority designates. The Canby population is about 160 and would not be considered an MS4. The project would not require a Storm Water Pollution Prevention Plan under the NPDES system as the project (1) would not involve significant amount of ground disturbance and potential for run-off, and (2) is not large enough to merit a SWPPP (Rohrbach 2002).

State/Local

California Division of Oil, Gas and Geothermal Resources (DOGGR). DOGGR oversees the drilling, operation, maintenance, plugging and abandonment of geothermal wells. The regulatory program emphasizes the wise development of geothermal resources in the state through sound engineering practices that protect the environment, prevent pollution, and ensure public safety.

In California, all geothermal wells on private and state lands are regulated by DOGGR, under provisions of the state Public Resources Code.

All drilling, reworking, and abandonment operations for geothermal wells on private and state lands require a permit from the DOGGR. If the well is being drilled as an exploratory project, an environmental study is required under the California Environmental Quality Act (CEQA), with the   acting as the lead agency. DOGGR engineers monitor all wells to ensure that they are operated properly. Monitoring includes reviewing operational data and running tests to assure the soundness of the well casing. In addition, DOGGR engineers inspect most well sites annually.

The project proponent obtained a DOGGR permit for the production well (API No. 049-90039) and the well was inspected after the shallow casing was set. The blowout prevention equipment and its installation for use during drilling was approved on April 13, 2000.

Central Valley Regional Water Quality Control Board. The primary agency for regulating surface water and groundwater pollution in California is the Regional Water Quality Control Board (RWQCB). The State Water Resources Control Board (SWRCB) delegates authority for implementation of regulations to the RWQCB, but creates general policies and plans. Once approved, these water quality control plans are implemented and enforced by the nine RWQCBs. The SWRCB and RWQCB are agencies within the California Environmental Protection Agency (CalEPA). The RWQCB determines allowable concentration limits for effluents, issues permits, and enforces regulations. The project area is within the jurisdiction of the Central Valley RWQCB.

Porter-Cologne Water Quality Control Act of 1998. The Porter-Cologne Water Quality Control Act of 1970 established the jurisdiction of the nine California RWQCBs, granting them the authority to issue Waste Discharge Requirements (WDRs) that impose annual discharge fees and establish discharge limits, operation and maintenance requirements for treatment equipment, and monitoring, record keeping, and reporting requirements. Discharge of waste to land, such as septic leach fields, must comply with the WDRs. Two policies applicable to the RWQCBs oversight of this project are: State Water Board Resolution 68-16, which prohibits a discharger from reducing the quality of discharge or groundwater, even though such a reduction of water quality may not directly impact beneficial uses associated with the water body; and State Water Board Resolution 88-63, which specifies that except with specific exceptions, all surface and groundwater of the State are to be protected as existing or potential sources of municipal and domestic supply.

As stated above, the regional board that regulates the proposed action is the Central Valley Regional Water Quality Control Board (CVRWQCB). The existing CVRWQCB Waste Discharge Order (R5-2002-0079) for the Canby Geothermal project is provided in Appendix D.

California Safe Drinking Water and Toxics Enforcement Act (Prop. 65). Through Cal EPA under the Office of Environmental Health Hazard Assessment (OEHHA) administration, actions are prohibited that contaminate drinking water with chemicals known to cause cancer or reproductive toxicity.

Modoc County General Plan. The Modoc County General Plan Goal, Policies, and Action Program states the following:

> "A significant opportunity relates to geothermal development. The economic potential of geothermal development is significant. The General Plan will enhance efforts to capitalize on geothermal energy development through the protection of known geothermal resources and the support, through land use policies, of locating geothermal using industries adjacent to the energy resource." (Mintier Harnish & Associates 1998b)

The Modoc County General Plan Goal, Policies, and Action Program includes the following policies pertinent to geothermal resources:

- Encourage the wise use of geothermal resources in the county.
- Continue efforts to use geothermal energy for public building space heating and warm water use.
- Designate industrial land uses adjacent to appropriately located geothermal resources.